Air-Ocean Modeling and Prediction System Development

James D. Doyle
Naval Research Laboratory
Monterey CA 93943-5502
phone: (831) 656-4716 fax: (831) 656-4769
e-mail: doyle@nrlmry.navy.mil
Award #: N0001498WX30333

LONG TERM GOALS

Increase our scientific understanding of the processes that are responsible for energy transport between the atmosphere and ocean and apply this knowledge to improve our ability to predict the atmosphere and ocean, particularly in their respective boundary layers. Enhance the Navy's tactical capabilities through better definition of the littoral battlespace environment.

OBJECTIVES

Study the effects and feedbacks that occur on the mesoscale between the atmosphere and ocean. For example, tropical and extratropical cyclones have been observed to change the circulation and temperature of the ocean, and coastal ocean processes such as upwelling occur as a direct result of atmospheric forcing. These oceanic changes can then, in turn, have an impact on the subsequent structure and behavior of the atmospheric boundary layer.

APPROACH

This project will utilize existing atmospheric, ocean, wave, and ice models, such as the Navy Operational Global Atmospheric Prediction System (NOGAPS), the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS), the Wave model (WAM), the Polar Ice Prediction System (PIPS), the Princeton Ocean Model (POM), the NRL Coastal Ocean Model (NCOM), and the Modular Ocean Model (MOM), to study issues related to developing fully coupled atmosphere/ocean prediction systems. Atmospheric models such as NOGAPS need to be coupled to MOM, PIPS, and WAM, while COAMPS is being developed as a fully coupled system of mesoscale atmospheric and ocean models. Tests of these interactive systems will give insight into the problems of tightly coupled air/ocean models (e.g., SST biases) and will guide ultimate development of fully interactive atmosphere/ocean (ice, wave, dynamical/physical) models. We will use Labrador Sea field experiment data to validate and improve the COAMPS boundary layer and to gain a greater understanding of air-sea interaction processes. High-resolution benchmark tests of COAMPS will be performed over the Labrador Sea for a 2-3 week period using data assimilation to incorporate all conventional observations. Field experiment data will be used to validate the performance of these simulations and to test impact in additional data assimilation experiments. Idealized tests will be conducted to examine the mesoscale flows that exist near coastlines that may have significant effects on the coastal ocean circulation(s). (Performers include James Doyle and Richard Hodur, NRL MRY; Xiaodong Hong, UCAR post-doc; and Paul May, Anteon contractor.)

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **1998**	2. REPORT TYPE	3. DATES COVERED **00-00-1998 to 00-00-1998**
4. TITLE AND SUBTITLE **Air-Ocean Modeling and Prediction System Development**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Research Laboratory,Monterey,CA,93943**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES **See also ADM002252.**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**3**	

WORK COMPLETED

Work continued to integrate the POM and the NCOM into COAMPS. Built interfaces in COAMPS for initialization of ocean depth, temperature, salinity, and currents for real and idealized simulations. The atmospheric analysis/prediction component of COAMPS, complete with its own real-time sea surface temperature and sea ice analysis, was used to provide real-time forecasts in support of the Labrador Sea experiment during January and February, 1998. Idealized and real-data numerical model simulations were made to investigate the dynamics of low-level jet streams or "tip jets" that form in stratified flow downstream of the vertex of large elliptical barriers, such as Greenland.

RESULTS

During the Labrador Sea experiment, COAMPS provided accurate forecasts of wind, temperature, moisture, and flux data. In an e-mail message concerning these COAMPS forecasts, Bob Pickart from Woods Hole Institute stated “You should be pleased to know that the Captain regularly exclaimed how much more accurate your forecasts were than the standard product they were receiving on the bridge. I was impressed again and again in the same regard.” The Labrador Sea data is currently being analyzed, and analyses of topographic flows near Greenland and their influence on air-sea interaction is being investigated. A manuscript has been submitted for publication describing the mesoscale modeling support for LABSEA.

An idealized model simulation was made for a typical wintertime stratified flow across a large elliptical barrier, similar to the shape of Greenland. In some circumstances, differential advection of the along-stream baroclinicity is a key factor in the formation and maintenance of the Greenland tip jet, in contrast to the more common situation where lateral deflection around the obstacle and differential adiabatic descent dominate. A downstream balance is achieved, characterized by baroclinicity associated with the surface-based tip jet, and manifested as a frontal zone, or "tip front", in first-order geostrophic-thermal balance with negative shear above the jet. The normalized tip-jet maximum is most sensitive to changes in the basic state Nh/U and Ro, underscoring the importance of the airstream lateral displacement around the obstacle. Air-sea exchange processes are enhanced at the tip jet, with large surface-heat fluxes (greater than 800 W m^{-2}) and local maxima and minima of the curl of the surface stress present. It is hypothesized that the surface fluxes and stresses associated with this jet play a significant role in the ocean circulation of the North Atlantic Ocean.

IMPACT

The skill of COAMPS for real-time, high-resolution atmospheric forecasts was further validated by the Labrador Sea Experiment. Operational users of COAMPS will continue to benefit from additional capabilities that will result from the research being conducted as part of this project. Those operational users include not only the Navy meteorological/oceanographic (METOC) community, but also a growing number of other defense-related agencies. An enhanced ability to define the littoral battlespace environment through the use of coupled air/ocean models will provide Navy forces with a unique capability to exploit the environment to their tactical advantage.

TRANSITIONS

Developments from this program will transition to an existing 6.4 program (PE 0603207N) for applications within COAMPS and ultimately for transition to Fleet Numerical Meteorology and Oceanography Center (FNMOC), as well as other potential sites, for operational use.

RELATED PROJECTS

A number of other research projects are closely related to this effort. These projects include work that focuses on the development of the ocean data assimilation (PE 0603785N) and ocean forecast model (PE 0602435N) components of COAMPS, and a 6.4 project that is funded by the Oceanographer of the Navy to provide for transitions of new capabilities that result from these development efforts, particularly those that extend the current operational ocean data assimilation capabilities. PE 0602435N also supports a 6.2 project within the NRL base program that will continue to develop the COAMPS atmospheric model and transition those improvements via 6.4 (PE 0603207N, task X-0513) to FNMOC.

PUBLICATIONS

Renfrew, I., G. W. K. Moore, T.R. Holt, S. W. Chang, 1998: Mesoscale forecasting during a field program: Meteorological support of the Labrador Sea Deep Convection Experiment. (conditionally accepted for publication *Bull. Amer. Met. Soc.*)